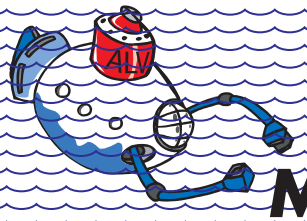


# Mapping Deep-sea Habitats

## Focus
Bathymetric mapping of deep-sea habitats

## Grade Level
5-6, 7-8 (Earth Science)

## Focus Question
How can deep-sea areas of the Northwest Hawaiian Islands be mapped to facilitate their exploration with a manned submersible?

## Learning Objectives
Students will be able to create a two-dimensional topographic map given bathymetric survey data.

Students will be able to create a three-dimensional model of landforms from a two-dimensional topographic map.

Students will be able to interpret two- and three-dimensional topographic data.

## Materials
- ❒ Copies of "Loihi Submarine Volcano Bathymetric Data;" one for each student group
- ❒ Copies of "Bathymetric Data Reduction Sheet;" one for each student group
- ❒ Tracing paper
- ❒ Pieces of foamcore display board, seven for each student group; 8-1/2" x 11" x 5/32" thick or 11" x 17" x 1/4" thick if students, maps are enlarged 200% (see Learning Procedure, step #2; these thicknesses will approximate the correct vertical scale)
- ❒ Glue, preferably spray type used for mounting photographs
- ❒ Sharp scissors or X-Acto knives for cutting cardboard

## Audio/Visual Materials
None

## Teaching Time
Two 45-minute class periods

## Seating Arrangement
Groups of four students

## Maximum Number of Students
32

## Key Words
Seamount
Bathymetry
Transducer
Backscatter
Topographic contour

## Background Information
Nearly 70% of all coral reefs in U.S. waters are found around the Northwestern Hawaiian Islands, a chain of small islands and atolls that stretches for more than 1,000 nautical miles (nm) northwest of the main Hawaiian Islands. While scientists have studied shallow portions of the area for many years, almost nothing is known about deeper ocean habitats below the range of SCUBA divers. Only a few explorations have been made with deep-diving submersibles and remotely-operated vehicles (ROVs), and these explorations have yielded

discoveries of new species and species previously unreported in Hawaiian waters.

Northwestern Hawaiian Islands are regularly visited by Hawaiian monk seals, one of only two species of monk seals remaining in the world (the Caribbean monk seal was declared extinct in 1994). Waters around the Northwestern Islands may be an important feeding area for the seals, which appear to feed on fishes that find shelter among colonies of deep-water corals. These corals are also of interest, because they include several species that are commercially valuable for jewelry. The possibility of discovering new species also has commercial importance as well as scientific interest, since some of these species may produce materials of importance to medicine or industry.

A major constraint to exploration of deep-water regions around the Northwestern Hawaiian Islands is the absence of accurate maps of the area. In fact, recent expeditions have found that some islands are not where they are supposed to be according to official nautical charts. Since underwater exploration time in submersibles is severely limited, every dive must be carefully planned to ensure that the submersible can go directly to places that are most likely to provide the information the scientists need. For this reason, underwater mapping is a top priority for the Ocean Exploration 2002 Northwestern Hawaiian Islands Expedition.

Scientists aboard the University of Hawaii's research vessel *Kilo Moana* will use multibeam swath bathymetry to create detailed pictures of the underwater topography around the Northwestern Hawaiian Islands. Multibeam swath bathymetry (also called "high-resolution multibeam mapping") uses a transducer (a sort of combination microphone/loudspeaker) mounted on the ship's hull to send out pulses of sound in a fan-shaped pattern below the ship, and then records sound reflected from the seafloor through a set of narrow receivers aimed at different angles on either side of the ship. This system collects high resolution water-depth data that can distinguish differences of less than a meter. The system also measures the amount of sound energy returned from the seafloor (called "backscatter"), which can help identify different materials (such as rock, sand, or mud) on the seafloor. The multibeam system is coupled to a global positioning system (GPS) that can pinpoint sea-floor locations within one meter. All data are collected in digital form, which allows them to be processed by computer to produce maps, three dimensional models, or even "fly-by" videos that simulate a trip across the area being mapped in a high-speed submersible! Topographic maps are one of the most common outputs from these systems. On these maps, areas with the same depth are connected by lines, so that mountains (or valleys) are shown as a series of concentric, irregular closed curves. Curves that are close together indicate steep topography, while curves that are farther apart show more gentle slopes.

This activity focuses on how topographic maps are created from multibeam bathymetric data. Students will construct a three-dimensional model of the Loihi submarine volcano from their topographic maps to help visualize the actual form of the seamount.

## Learning Procedure

1. Introduce the location of the Northwestern Hawaiian Islands, and point out some of the features that make this area important (discussed above). Discuss the need for accurate maps in planning diving expeditions to deep-sea regions, and explain the general concept of multibeam swath bathymetry. You may need to review the basic idea of topographic maps if students are unfamiliar with these.

2. Distribute copies of "Loihi Volcano Bathymetric Data" and "Bathymetric Data Reduction Sheet" to each student group. Tell the students that the bathymetric data are part of a data set that was produced by a research vessel using multibeam bathymetry. Be sure students understand that each data point represents the depth of water below the research vessel when the vessel was at the location described by the grid coordinates. If you want to relate the grid to an actual map location, the lower left corner of grid cell 1,1 corresponds to latitude 18°-45'N, longitude 155°-20'W. Each grid cell interval corresponds to one minute of latitude or longitude. Note that for the purposes of this exercise, we are not dealing with all of the side-scan data, which would include more than a hundred additional depth readings in each grid cell, and would be much more difficult to process without computer analysis.

   Have each group enter the depth readings from the bathymetric data sheet into the corresponding grid cells on the "Bathymetric Data Reduction Sheet." Next, have the students draw contour lines on the Data Reduction Sheet for depths of 1,000 m, 2,000 m, 3,000 m, and 4,000 m. Tell the students to assume that the depth reading was taken at the center of each grid cell (indicated on the Data Reduction Sheet by the light crossed diagonal lines). In most cases, students will have to interpolate the position of the contour lines; for example, if one grid cell has a depth reading of 2,800 m and an adjacent cell has a depth reading of 3,200 m, students should assume that the 3,000 m contour line passes halfway between the center points of the two cells. Once these three contour lines are drawn, have students draw intermediate contour lines at 500 m intervals (i.e., 1,500 m, 2,500 m, and 3,500 m). When students have completed their contour maps, have them make a master tracing, and seven photocopies. If you want them to make larger models, they can enlarge their master tracing on the photocopier.

3. Have the students mount each copy of their contour map onto a piece of cardboard. Be sure to use enough glue to cover the entire surface of the cardboard. Next, students should prepare the seven layers of their three dimensional model by cutting along the 4,000 m contour line on one mounted map, then cutting along the 3,500 m contour on the next mounted map, and so on until three layers have been cut out corresponding to each of the seven contour lines constructed on the Data Reduction Sheet. If students are

using X-Acto knives, be sure to have a suitable backing (heavy cardboard, cutting board, etc.) to protect work surfaces.

4. Starting with the 4,000 m contour, carefully glue successive contours together to build the three-dimensional model of the volcano.

5. Using the models the students have produced, discuss the advantages of various locations on the volcano for diving missions. Flat regions are more likely to have accumulations of sediment, and will provide different habitats than very steep areas. On the other hand, steep areas obviously have a greater range of depths within a short distance, so these are better sites to study how depth influences the distribution of various species. Identify areas that are likely to offer a variety of habitat types within a short distance. These offer some of the best opportunities to get the most out of limited diving time.

Have the students compare their models with the bathymetric image of the Loihi volcano at http://www.oar.noaa.gov/spotlite/archive/spot_loihi.html. This image provides much more detail than the students' topographic maps because it includes thousands more data points. This sort of detailed mapping is only possible when computer analysis is available.

## The BRIDGE Connection

www.vims.edu/BRIDGE/pacific.html

## The "Me" Connection

Have students write a first-hand account of an exploratory mission to the Loihi volcano, referring to topographic features revealed by their model.

## Connections to Other Subjects

English/Language Arts, Mathematics

## Evaluation

Have students write a description of the Loihi volcano based on their model. Have them include geographic location (north-south-east-west directions and/or latitude and longitude), topography (steepness), and depth. Ask them to discuss the advantages and disadvantages of two-dimensional and three-dimensional topographic maps.

## Extensions

Have students visit http://oceanexplorer.noaa.gov to follow the progress of deep-sea mapping in the vicinity of the Northwestern Hawaiian Islands. Additional data sets for topographic map construction may be posted here as the Expedition proceeds.

## Resources

http://oceanexplorer.noaa.gov – Follow the Northwestern Hawaiian Islands Expedition daily as documentaries and discoveries are posted each day for your classroom use.

http://geopubs.wr.usgs.gov/fact-sheet/fs013-00/fs013-00.pdf – Fact sheet on multi-beam mapping

http://www.oar.noaa.gov/spotlite/archive/spot_loihi.html – Short article on the Loihi volcano

http://www.soest.hawaii.edu/GG/HCV/loihi.html – More extensive website with information on Loihi and other volcanoes in Hawaii

http://newton.physics.wwu.edu:8082/jstewart/scied/earth.html – Earth science education resources
http://www.sciencegems.com/earth2.html – Science education resources

http://www-sci.lib.uci.edu/HSG/Ref.html – References on just about everything

## National Science Education Standards

**Content Standard A: Science As Inquiry**

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

**Content Standard D: Earth and Space Science**

- Structure of the Earth system

*Activity developed by Mel Goodwin, PhD, The Harmony Project, Charleston, SC*

# Loihi Submarine Volcano Bathymetric Data

| Grid Cell (row, column) | Depth (m) |
|---|---|
| 1,1 | no data |
| 1,2 | no data |
| 1,3 | no data |
| 1,4 | 4600 |
| 1,5 | 4400 |
| 1,6 | 4400 |
| 1,7 | 4000 |
| 1,8 | 3800 |
| 1,9 | 3600 |
| 1,10 | 3300 |
| 1,11 | 2700 |
| 1,12 | 2400 |
| 1,13 | 2500 |
| 1,14 | 2600 |
| 1,15 | 2800 |
| 2,1 | no data |
| 2,2 | no data |
| 2,3 | no data |
| 2,4 | 4200 |
| 2,5 | 4100 |
| 2,6 | 4100 |
| 2,7 | 3900 |
| 2,8 | 3400 |
| 2,9 | 3200 |
| 2,10 | 2800 |
| 2,11 | 2400 |
| 2,12 | 2200 |
| 2,13 | 2300 |
| 2,14 | 2300 |
| 2,15 | 2400 |
| 3, 1 | no data |
| 3,2 | no data |
| 3,3 | no data |
| 3,4 | 4000 |
| 3,5 | 3800 |
| 3,6 | 3800 |
| 3,7 | 3700 |
| 3,8 | 3300 |
| 3,9 | 2800 |
| 3,10 | 2400 |
| 3,11 | 2000 |
| 3,12 | 1900 |
| 3,13 | 2000 |
| 3,14 | 21 |
| 3,15 | 2200 |
| 4,1 | no data |
| 4,2 | no data |
| 4,3 | 4400 |
| 4,4 | 3800 |
| 4,5 | 3500 |
| 4,6 | 3200 |
| 4,7 | 2800 |
| 4,8 | 2800 |
| 4,9 | 2300 |
| 4,10 | 1800 |
| 4,11 | 1400 |
| 4,12 | 1500 |
| 4,13 | 1600 |
| 4,14 | 1800 |
| 4,15 | 1900 |
| 5,1 | no data |
| 5,2 | no data |
| 5,3 | 4600 |
| 5,4 | 4000 |
| 5,5 | 3400 |
| 5,6 | 2900 |
| 5,7 | 2300 |
| 5,8 | 1800 |
| 5,9 | 1600 |
| 5,10 | 1000 |
| 5,11 | 1100 |
| 5,12 | 1200 |
| 5,13 | 1400 |
| 5,14 | 1600 |
| 5,15 | 1800 |
| 6,1 | no data |
| 6,2 | no data |
| 6,3 | 4500 |
| 6,4 | 4000 |
| 6,5 | 3400 |
| 6,6 | 2700 |
| 6,7 | 2000 |
| 6,8 | 1800 |
| 6,9 | 1600 |
| 6,10 | 1300 |
| 6,11 | 1200 |
| 6,12 | 1700 |
| 6,13 | 2000 |
| 6,14 | 2200 |
| 6,15 | 2000 |
| 7,1 | 4500 |
| 7,2 | 4400 |
| 7,3 | 4000 |
| 7,4 | 3800 |
| 7,5 | 3000 |
| 7,6 | 2400 |
| 7,7 | 2400 |
| 7,8 | 2300 |
| 7,9 | 2300 |
| 7,10 | 2500 |
| 7,11 | 2500 |
| 7,12 | 2700 |
| 7,13 | 2900 |
| 7,14 | 3000 |
| 7,15 | 2500 |
| 8,1 | 4500 |
| 8,2 | 4000 |
| 8,3 | 3600 |
| 8,4 | 3100 |
| 8,5 | 3000 |
| 8,6 | 3200 |
| 8,7 | 3200 |
| 8,8 | 3100 |
| 8,9 | 3000 |
| 8,10 | 3100 |
| 8,11 | 3100 |
| 8,12 | 3200 |
| 8,13 | 3200 |
| 8,14 | 3200 |
| 8,15 | 2800 |
| 9,1 | 4400 |
| 9,2 | 4000 |
| 9,3 | 3600 |
| 9,4 | 3400 |
| 9,5 | 3900 |
| 9,6 | 4000 |
| 9,7 | 3800 |
| 9,8 | 3700 |
| 9,9 | 3600 |
| 9,10 | 3800 |
| 9,11 | 3600 |
| 9,12 | 3500 |
| 9,13 | 3400 |
| 9,14 | 3300 |
| 9,15 | 3200 |
| 10,1 | 4500 |
| 10,2 | 4200 |
| 10,3 | 4200 |
| 10,4 | 4700 |
| 10,5 - 10,15 | no data |
| 11,1 | 4700 |
| 11,2 | 4500 |
| 11,3 | 4700 |
| 11,4 - 11,15 | no data |

## Bathymetric Data Reduction Sheet